# Vein Patch Angioplasty with Internal Mammary Artery Grafting of the Left Anterior Descending Coronary Artery

Adrian E. Manapat, MD and Eduardo R. Bautista, MD

*Division of Thoracic, Cardiac and Vascular Surgery, Department of Surgery,*
*College of Medicine and Philippine General Hospital, University of the Philippines Manila*

## ABSTRACT

**Objective.** To describe the treatment outcomes of patients who underwent coronary artery bypass grafting (CABG) with vein patch angioplasty with internal mammary artery (IMA) grafting of the diffusely diseased left anterior descending (LAD) coronary artery.

**Methods.** This is a retrospective observational study of 26 patients who have undergone vein patch angioplasty of the LAD coronary artery with IMA grafting in three centers by a single surgeon from January 2012 to August 2017. The demographic profile, intraoperative data, and postoperative outcome (including in-hospital mortality and morbidity, perioperative myocardial infarction, and NYHA functional classification) were recorded. Continuous variables were expressed as means with standard deviation and categorical variables summarized as frequencies and percentages. Student's t-test was used to compare the preoperative versus postoperative mean NYHA functional class.

**Results.** There were 22 (85%) males and 4 (15%) females with a mean age of 62 years (range: 34 to 82). Twenty-five patients (96%) had a three-vessel disease, and one (4%) had a two-vessel disease. Nine patients (35%) had a preoperative myocardial infarction. The mean cardiopulmonary bypass and aortic-cross clamp times were 156 and 118 minutes, respectively. The mean number of vessels grafted was 4.12. Multiple arterial grafting was used in seven patients (27%). There were two in-hospital mortalities (7.7%) and three morbidities (11.5%), including reoperation for bleeding, acute kidney injury, and leg wound infection. Six patients (23%) developed postoperative atrial fibrillation. No patient developed perioperative myocardial infarction. The mean ICU stay was three days, and the mean hospital stay was 10.27 days. The mean NYHA functional class improved from 2.85 preoperatively to 1.5 postoperatively ($p$<0.00001). Among patients with improvement, postoperative NYHA improved by two functional classes in 38% and by one functional class in 62%.

**Conclusion.** Vein patch angioplasty is a valuable technique for diffuse coronary stenosis of the LAD artery with acceptable early results.

*Keywords: vein patch angioplasty, coronary artery bypass grafting (CABG)*

CC BY NC ND

eISSN 2094-9278 (Online)
Published: April 15, 2024
https://doi.org/10.47895/amp.vi0.7645

Corresponding author: Adrian E. Manapat, MD
Division of Thoracic, Cardiac and Vascular Surgery
Department of Surgery
Philippine General Hospital
University of the Philippines Manila
Taft Avenue, Ermita, Manila 1000, Philippines
Email: amanapat@gmail.com
ORCiD: https://orcid.org/0009-0000-7169-0916

## INTRODUCTION

Complete coronary arterial revascularization is the optimal goal in coronary artery bypass grafting (CABG). Incomplete revascularization, mainly involving the left anterior descending coronary artery (LAD), is one of the most critical factors affecting long-term mortality and morbidity.[1] Although most coronary stenotic lesions are in the proximal segment, there are instances when the artery has multiple segmental critical lesions at its middle portion, or it is so diffusely diseased leaving no suitable site for anastomosis. The widespread popularity of and preference for percutaneous coronary intervention (PCI) over CABG has resulted in a

higher percentage of patients with this more complex coronary anatomy pattern being referred for surgical revascularization. At the same time, the rest are usually managed with PCI. This subset of patients being referred for CABG with increasing frequency poses a challenge to the cardiac surgeon who wants to achieve complete revascularization.[2]

In a diffusely diseased artery, the surgeon may perform coronary endarterectomy, removing the atherosclerotic plaque prior to coronary bypass. The technique, first reported by Bailey[3], has historically been associated with increased morbidity (including perioperative myocardial infarction) and mortality.[4] This may be due to thrombogenesis from vessel trauma and embolization. It has been a sparingly used technique until the changing anatomic profile of CABG patients brought about its re-emergence over the past three decades.[4]

In the case of multi-segmental lesions, bypassing only the LAD's most distal lesion would jeopardize the proximal portion and its corresponding myocardial territory. One option is placing two separate grafts on the LAD (one distal to the first and the other distal to the second segmental lesion). The disadvantage is the possibility of competitive flow, sometimes seen in coronary arteries with multiple inflow sources.[5]

An alternative technique, patch angioplasty, utilizes an arteriotomy (with or without a short endarterectomy) across the more distally located atherosclerotic plaque and patch reconstruction with saphenous vein prior to the anastomosis of the left internal mammary artery (LIMA).[6-8] It is easier to perform, causes less arterial trauma with consequently less possibility of thrombosis than endarterectomy, and avoids the potential for competitive flow seen in multiple grafts on the same artery.

There are few published data describing vein patch angioplasty. Most of the reports from foreign literature cite it as a safe and feasible option with acceptable clinical outcomes in this subgroup of patients.[7,8] There is no locally published data.

This study aimed to review the clinical experience of the author in the use of vein patch angioplasty with IMA grafting of the LAD in CABG. The objectives of this study were to determine:

1. The demographic profile of patients who underwent vein patch angioplasty with IMA grafting of the LAD.
2. The outcomes of surgical treatment, morbidity, and in-hospital mortality rates.

## METHODS

This retrospective observational study involved 26 patients who have undergone elective CABG using vein patch angioplasty as performed by the author from January 2012 to August 2017 in three medical centers, namely, the Philippine General Hospital, The Medical City, and Makati Medical Center. Patients with prior cardiac surgery, concomitant or additional procedures, and emergency surgery were excluded.

The institutions' available databases and operation logbooks were used to identify patients for inclusion. The inpatient charts and clinic records were reviewed, and the demographic data were recorded. The following intraoperative and postoperative data were likewise recorded: the number of vessels grafted, conduits used, cardiopulmonary bypass time, aortic cross-clamp time, total mediastinal blood loss, length of ICU stay, prolonged use of inotropic support (more than 24 hours), need for intra-aortic balloon pumping (IABP), duration of mechanical ventilation, the occurrence of atrial fibrillation, myocardial infarction, complications, death, length of ICU and hospital stay, and NYHA classification at one to two months. Morbidity and in -hospital mortality rates were calculated. Demographic, preoperative, intraoperative, and postoperative data were described with continuous variables expressed as means with standard deviation and categorical variables summarized as percentages. Student's t-test was used to compare the preoperative versus postoperative mean NYHA functional class. The University of the Philippines Manila Research Ethics Board approved the study protocol.

### Surgical technique

All procedures were performed through a median sternotomy using mild hypothermic cardiopulmonary bypass with ascending aortic, two-stage venous cannulation, and antegrade-retrograde cold blood cardioplegia. The conduits used for CABG included single internal mammary artery (SIMA) or bilateral internal mammary arteries (BIMA), greater saphenous vein, and the non-dominant radial artery. The left anterior descending artery was opened last (after all the other distal coronary targets had been addressed), just beyond the most distal lesion. To avoid competitive flow, the arteriotomy was extended across the plaque or plaques up to a point distal to the most proximal lesion. In cases where the needle could not be passed through the calcified plaque, a short segment endarterectomy was performed. The arteriotomy (usually 2 to 4 cm) was then patched with a saphenous vein segment in an onlay fashion with a continuous running polypropylene 7-0 suture. The proximal end of the vein is doubly ligated with a non-absorbable suture close to the anastomosis, and double clips were applied. The left or right internal mammary artery was then anastomosed to the vein patch using a polypropylene 7-0 suture (Figures 1 and 2). The proximal saphenous vein-aortic anastomoses were usually carried out with a partial occluding aortic clamp unless the aorta was calcified (in which case, they are done with a single cross-clamp technique).

## RESULTS

Out of 293 patients who underwent CABG in the author's experience during the study period, twenty-eight patients (9.55%) underwent vein patch angioplasty but only twenty-six (93%) medical records could be recovered. The mean age was 62 years (±12.4), ranging from 34 to 82 years.

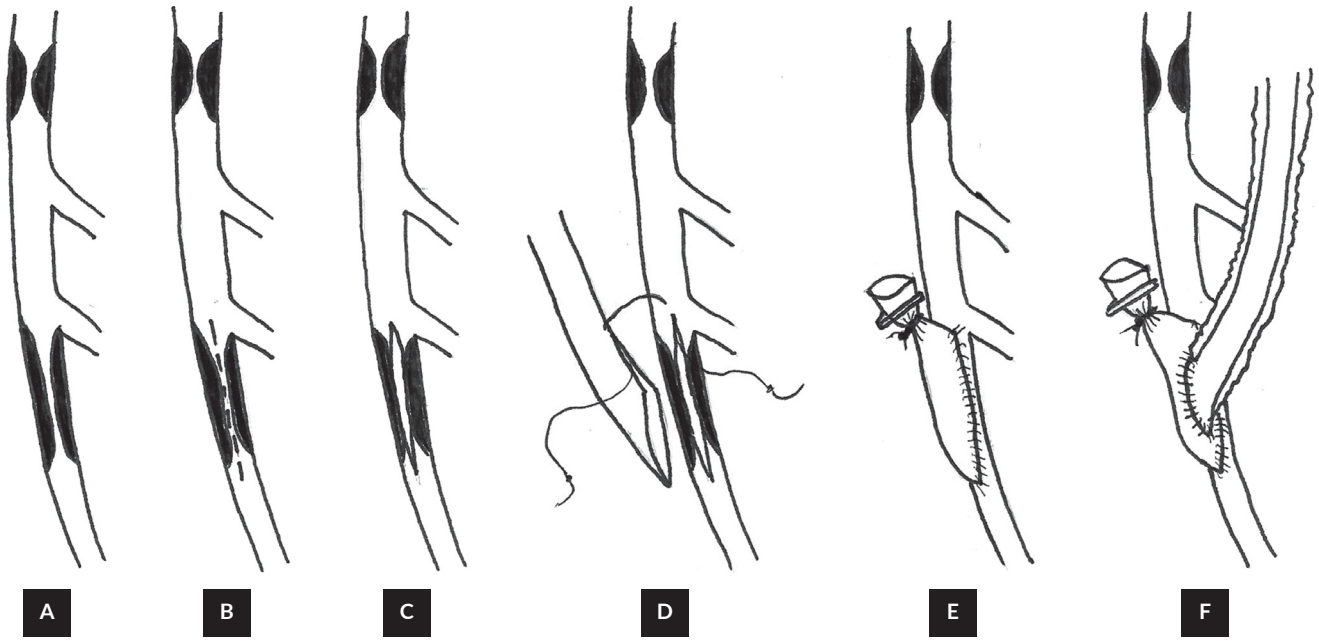


**Figure 1.** ***Steps in vein patch angioplasty with CABG.*** **(A)** LAD with segmental stenoses. **(B)** Proposed line of arteriotomy on the LAD *(dashed line)*. **(C)** Arteriotomy splitting the plaque of the distal stenosis. **(D)** Saphenous vein anastomosis to the LAD. **(E)** Completed vein patch on the LAD. **(F)** LIMA has been anastomosed to the vein patch on the LAD.

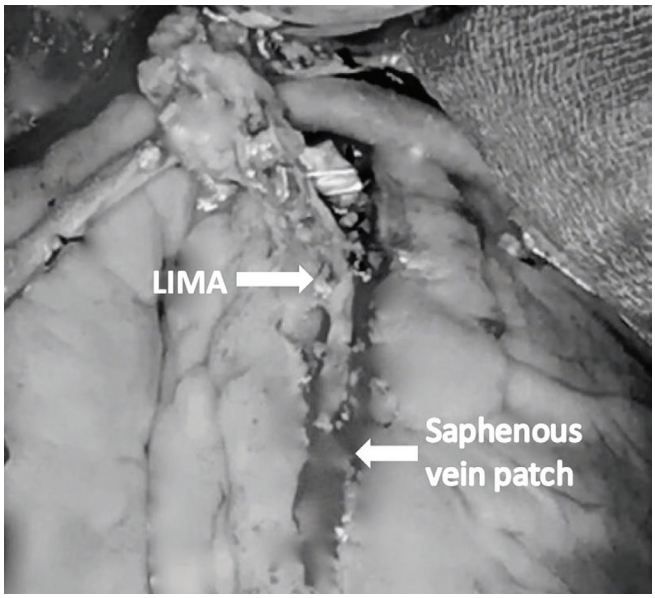


**Figure 2.** Left internal mammary artery anastomosed to vein patch of the left anterior descending artery (LAD).

**Table 1.** Cardiac Profile and Concomitant Diseases of Patients who Underwent Coronary Artery Bypass Grafting (CABG) with Vein Patch Angioplasty

| | Number | Percentage |
|---|---|---|
| Hypertension | 24 | 92 |
| Diabetes mellitus | 22 | 85 |
| Dyslipidemia | 19 | 73 |
| Smoking history | 15 | 58 |
| Recent Myocardial infarction | 9 | 35 |
| Cerebrovascular disease | 10 | 38 |
| Peripheral artery disease | 2 | 8 |
| Renal Failure | 11 | 42 |
| Chronic obstructive pulmonary disease | 3 | 12 |
| Left main coronary involvement | 4 | 15 |
| Three-vessel disease | 25 | 96 |
| Two-vessel disease | 1 | 4 |
| Obesity (BMI ≥30 kg/m$^2$) | 3 | 12 |
| NYHA functional class I | 1 | 4 |
| NYHA functional class II | 7 | 27 |
| NYHA functional class III | 13 | 50 |
| NYHA functional class IV | 5 | 19 |

*NYHA: New York Heart Association, BMI: body mass index*

Eighty-five percent were males. Twenty-five (96%) patients had a three-vessel disease, and one (4%) had a two-vessel disease. Four (15%) had left main trunk involvement. Table 1 shows other important patient characteristics. Majority had hypertension (92%), diabetes mellitus (85%), dyslipidemia (73%), and renal failure (42%).

All patients underwent elective or urgent surgery. One (4%) patient was classified as NYHA (New York Heart Association) functional class I, seven (27%) were class II, thirteen (50%) were class III, and five (19%) were class IV. The mean ejection fraction was 58.8% (34% to 87%).

The preoperative cardiac EF (ejection fraction) and intraoperative data are summarized in Table 2. The mean

**Table 2.** Preoperative Cardiac Profile and Intraoperative Data of Patients who Underwent CABG with Vein Patch Angioplasty

| Preoperative and intraoperative details | Mean | SD |
|---|---|---|
| Preoperative ejection fraction, *%* | 58.8 | 12.86 |
| NYHA Functional Class, mean | 2.85 | 0.78 |
| Cardiopulmonary bypass time, *minutes* | 156 | 30.5 |
| Aortic cross clamp time, *minutes* | 117.6 | 24.4 |
| Number of vessels grafted | 4.1 | 0.86 |

*NYHA: New York Heart Association*

**Table 3.** Arterial Conduits used in Patients who Underwent CABG with Vein Patch Angioplasty

| | Number | Percentage |
|---|---|---|
| Single internal mammary artery | 19 | 73.0 |
| Bilateral internal mammary artery | 5 | 19.0 |
| Left internal mammary artery + Radial artery | 1 | 3.8 |
| Bilateral mammary artery + Radial artery | 1 | 3.8 |

**Table 4.** Postoperative Outcomes in Patients who Underwent CABG with Vein Patch Angioplasty

| | Number | Percentage |
|---|---|---|
| Need for inotropic support >24 hours | 3 | 11.5 |
| Need for IABP | 1 | 3.8 |
| Mean mediastinal blood loss, *ml.* | 725 | |
| Reoperation for bleeding | 1 | 3.8 |
| Infection (leg wound) | 1 | 3.8 |
| Acute kidney injury | 1 | 3.8 |
| Mean duration of mechanical ventilation, *hours* | 5.4 | |
| Mean length of ICU stay, *days* | 3 | |
| Mean hospital stay, *days* | 10.27 | |
| Postoperative atrial fibrillation | 6 | 23.0 |
| In-hospital death | 2 | 7.7 |
| Mean NYHA functional class at one to two months | 1.5 | |
| Improved NYHA functional class at two months | 21 | 81.0 |

*IABP: intra-aortic balloon counterpulsation, ICU: intensive care unit, NYHA: New York Heart Association*

cardiopulmonary bypass time was 156 minutes, and the mean aortic-cross clamp time was 117.6 minutes. The number of vessels grafted ranged from three to six, with a mean of 4.1.

The left internal mammary artery was anastomosed to the vein patch in 24 patients, while the right internal mammary artery was used for this purpose in two cases. Seven patients (27%) had at least two arterial conduits. Bilateral internal mammary artery (BIMA) grafting was employed in five patients, LIMA plus radial artery in one patient, and BIMA plus radial artery in one patient (Table 3).

The postoperative outcomes are shown in Table 4. The mean total mediastinal blood loss was 725 ml. One patient required reoperation for bleeding. The mean duration of immediate postoperative mechanical ventilation was 5.4 hours. The mean length of ICU stay was three days, and the length of postoperative hospital stay was 10.27 days. Six (23%) patients developed atrial fibrillation which were treated medically.

None of the patients developed perioperative myocardial infarction based on ECG and clinical parameters. Cardiac enzyme levels were not routinely determined in this series of patients. Three patients (11.5%) required prolonged inotropic support, two of whom expired. The first mortality was a 67-year-old male who was in NYHA class IV, had acute renal failure and hospital-acquired pneumonia pre-operatively. His postoperative course was complicated by recurrence of ventilator-associated pneumonia, respiratory failure, sternal wound dehiscence requiring reoperation and cerebrovascular disease. He succumbed on the 24$^{th}$ post-operative day. The other mortality was a 64-year-old female who had a history of myocardial infarction four weeks prior during a gall bladder operation. On the second post-operative day, she developed acute hepatic failure with encephalopathy. Her hemodynamic status subsequently deteriorated and required inotropic and IABP support. She succumbed on the fifth postoperative day.

The other morbidities included one acute kidney injury (on top of chronic kidney disease) requiring temporary hemodialysis and one leg wound abscess managed with drainage. Six patients (23%) developed atrial fibrillation.

Eighty one percent of patients had an improved NYHA functional class after surgery. Mean NYHA functional class improved from preoperative 2.85 to 1.5 at two months post-operatively. The difference between preoperative and post-operative NYHA classification was statistically significant ($p$<.00001).

## DISCUSSION

The LAD's multi-segmental or diffuse atherosclerotic involvement requires reconstructive techniques in conjunction with conventional CABG. Vein patch angioplasty involves lengthening the arteriotomy to cross the midsegment lesion(s) and using an onlay saphenous vein patch before conventional anastomosis between the conduit and the patch. Unlike endarterectomy, it does not involve the removal of the tunica intima or media but merely a full thickness splitting of discrete anterior vessel plaques.

The technique is an option for short, discrete, multi-segmental (usually two) stenoses of the coronary artery (such as the LAD) as seen on the preoperative coronary angiogram. Intraoperatively, the surgeon can readily locate the second segmental lesion (usually in the middle segment of the artery). The arteriotomy is performed just distal to this then extended proximally by cutting through the stenotic area. The most proximal stenosis is left untouched since the artery would be revascularized by grafting with the LIMA. On the other hand, diffusely diseased coronaries involving long segments or majority of the entire length of the artery are better treated with coronary endarterectomy.

Vein patch angioplasty with LIMA anastomosis to the patch has been reported by several authors with good early and medium-term results.[6-8] Alternatively, the successful use of the LIMA alone as an onlay patch for the extended arteriotomy with acceptable early and midterm results has also been described.[9-11] Others have performed the LAD reconstruction with the LIMA using an off-pump procedure with very good early and midterm results.[12] Conversely, coronary endarterectomy is a technically more demanding option associated with longer cardiopulmonary and aortic cross-clamp times. Activation of the coagulation cascade due to loss of intima in the initial stages and myofibro-intimal proliferation in later stages have been postulated to predispose to coronary thrombosis.[13]

We prefer to use the saphenous vein over the internal mammary artery onlay patch because of the relatively small size of the internal mammary artery among Filipinos (which comprise the majority in this series). While patch angioplasty can be performed as an off-pump procedure, we prefer it under cardiopulmonary bypass like most other authors.[10] We performed short segment or limited endarterectomy in conjunction with vein patch angioplasty in three instances when the needle could not be passed through the calcified plaque. We reserve long-segment endarterectomy for severely calcified diffusely diseased vessels with no suitable segment for anastomoses.

This series' cardiopulmonary bypass and aortic cross-clamp times were within safe standards. The mean aortic cross-clamp time and cardiopulmonary bypass time were 117 and 156 minutes, respectively, with a mean of 4.12 vessels grafted.

Three patients required inotropic support for more than 24 hours. Two of these patients were on inotropic support preoperatively. The third patient deteriorated on the second hospital day because of liver failure and later required intra-aortic balloon pump (IABP) counter-pulsation.

The mean duration of immediate postoperatively ventilatory support was 5.4 hours. Two patients required re-establishment of ventilatory support for postoperative complications and eventually expired. The mean postoperative ICU stay was three days. The two deaths accounted for a mortality rate of 7.7%. No patient developed myocardial infarction based on ECG and clinical criteria. Unfortunately, cardiac enzymes were not routinely determined for all patients. The morbidity rate was 11.5%. The morbidities included reoperation for bleeding, acute kidney injury, and leg wound infection. The mean length of stay was 10.27 days.

Patients who undergo LAD reconstruction (particularly with endarterectomy) have higher operative mortality and postoperative myocardial infarction rate than conventional CABG.[4,14] This difference may reflect the severity of the atherosclerotic disease rather than the surgical technique.[9] Vein patch angioplasty has a mortality rate of 1.2 to 4.8% while the perioperative myocardial infarction ranged from 0-8%.[6-8] The overall reported mortality for long segment LAD reconstruction with endarterectomy ranged from 2.5 to 10%.[9] Bitan compared vein patch angioplasty and endarterectomy patients and found similar short-term survival and freedom from myocardial infarction. He concluded that both techniques were considered applicable. Although a lower reintervention rate was seen in the endarterectomy group in his series, this has not been corroborated by other authors.[15]

Although the mortality rate in this series is slightly higher than those reported by others, there was no myocardial infarction. The mortalities were not cardiac or related to vein patch angioplasty.

Out of 26 patients, 24 were discharged. The patients were routinely followed up for one to two months. The difference between the preoperative and postoperative mean NYHA functional class was significant (2.85 vs. 1.5, $p<0.00001$). Twenty-one (88%) patients had improved NYHA functional class. One remained at baseline functional class I status (4%), while two (8%) with NYHA functional class II did not improve. These included one patient who developed pleural effusion, requiring thoracentesis, and another with persistent atrial flutter. Of those who improved, eight (38%) improved by two or more functional classes, while thirteen (62%) improved by one functional class.

There are no existing guidelines on the use of anti-coagulation after vein patch angioplasty. Some routinely use low molecular weight heparin immediately postoperatively and bridge to warfarin for three months followed by aspirin only, others use intravenous heparin with low-dose aspirin and ticlopidine10 or aspirin and clopidogrel.[6,7,15] Our patients were started on aspirin or clopidogrel within the first 24 hours and continued as maintenance therapy.

This report is not meant to be a comparison between coronary endarterectomy and vein patch angioplasty but, rather, it presents an alternative option in addressing a specific subset of patients – those with distinct multisegmental stenosis of the LAD.

The small sample size and retrospective nature limit this study. Postoperative cardiac enzyme determination was not routinely performed. A longer follow-up period would help determine medium-term results.

## CONCLUSION

Twenty-six cases of vein patch angioplasty from the author's experience were presented. Vein patch angioplasty with IMA grafting is a useful technique for multi-segmental lesions or diffuse disease of the left anterior descending coronary artery with acceptable early results.

### Statement of Authorship

Both authors certified fulfillment of ICMJE author-ship criteria.

## Author Disclosure

Both authors declared no conflicts of interest.

## Funding Source

None.

## REFERENCES

1. Lawrie GM, Morris, GC Jr, Silvers A, Wagner WF, Baron AE, Beltangady SS, et al. The influence of residual disease after coronary bypass on the 5-year survival rate of 1274 men with coronary artery disease. Circulation. 1982 Oct;66(4):717-23. doi: 10.1161/01.cir.66.4.717.
2. Vohra HA, Kanwar R, Khan T, Dimitri WR. Early and late outcome after off-pump coronary artery bypass graft surgery with coronary endarterectomy: a single-center 10-year experience. Ann Thorac Surg. 2006 May;81(5):1691-6. doi: 10.1016/j.athoracsur.2005.12.028.
3. Bailey CP, May A, Lemmon WM. Survival after coronary endarterectomy in man. J Am Med Assoc. 1957 Jun;164(6):641-6. doi: 10.1001/jama.1957.02980060017005.
4. Soylu E, Harling L, Ashrafian H, Casula R, Kokotsakis J, Athanasiou T. Adjunct coronary endarterectomy increases myocardial infarction and early mortality after coronary artery bypass grafting: a meta-analysis. Interactive Cardiovasc Thorac Surg. 2014 Sep;19(3):462-73. doi: 10.1093/icvts/ivu157.
5. Kolozsvari R, Galajda Z, Ungvari T, Szabo G, Racz I, Szerafin T, et al. Various clinical scenarios leading to development of the string sign of the internal thoracic artery after coronary bypass surgery: the role of competitive flow, a case series. J Cardiothorac Surg. 2012 Jan;7:12. doi: 10.1186/1749-8090-7-12
6. Santini F, Casali G, Lusini M, D'Onofrio A, Barbieri E, Rigatelli G, et al. Mid-term results after extensive vein patch reconstruction and internal mammary grafting of the diffusely diseased left anterior descending coronary artery. Eur J Cardiothorac Surg. 2002 Jun;21(6):1020-5. doi: 10.1016/s1010-7940(02)00074-x.
7. Demir T. Vein patch angioplasty combined with left internal thoracic artery bypass to left anterior descending artery in patients having diffuse complex atherosclerotic lesions. Medeniyet Medical Journal. 2016;31(2):82-7. doi:10.5222/MMJ.2016.082
8. Attia A, Elsrawy E. Patch angioplasty in diffusely diseased left anterior descending coronary artery. J Cardiol Curr Res. 2014;1(5):150-3 doi: 10.15406/jccr.2014.01.00030
9. Barra JA, Bezon E, Mondine P, Resk A, Gilard M, Boshat J. Coronary artery reconstruction for extensive coronary disease: 108 patients and two-year follow up. Ann Thorac Surg. 2000 Nov;70(5):1541-5. doi: 10.1016/s0003-4975(00)01918-4.
10. Fukui T, Takanashi S, Hosoda Y. Long segmental reconstruction of diffusely diseased left anterior descending coronary artery with left internal thoracic artery with or without endarterectomy. Ann Thorac Surg. 2005 Dec;80(6):2098-105. doi: 10.1016/j.athoracsur.2005.06.047.
11. Ogus TN, Basaran M, Selimoglu O, Yildirim T, Ogus H, Ozcan H, et al. Long-term results of the left anterior descending coronary artery reconstruction with left internal thoracic artery. Ann Thorac Surg. 2007 Feb;83(2):496-501. doi: 10.1016/j.athoracsur.2006.09.073.
12. Prabhu AD, Thazhkuni IE, Rajendran S, Thamaran RA, Vellachamy KA, Vettath MP. Mammary artery patch reconstruction of left anterior descending coronary artery. Asian Cardiovasc Thorac Ann. 2008 Aug;16(4):313-7. doi: 10.1177/021849230801600412.
13. Walley VM, Byard RW, Keon WJ. A study of the sequential morphologic changes after manual coronary endarterectomy. J Thorac Cardiovasc Surg. 1991 Dec;102(6): 890-4.
14. Wang J, Gu C, Yu W, Gao M, Yu Y. Short- and long-term patient outcomes from combined coronary endarterectomy and coronary artery bypass grafting: a meta-analysis of 63,730 patients (PRISMA). Medicine (Baltimore). 2015 Oct;94(41):e1781. doi:10.1097/MD.0000000000001781
15. Bitan O, Pirundini PA, Leshem E, Consalvi C, McGurk S, King Q, et al. Coronary endarterectomy or patch angioplasty for diffuse left anterior descending artery disease. Thorac Cardiovasc Surg. 2018 Sep;66(6):491-7. doi: 10.1055/s-0037-1600918